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Studies on Ectomycorrhizae V.*

Mycorrhizae formed by *Dermocybe cinnamomea* and *D. sanguinea* on Spruce

by

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With 5 figures and 4 plates

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Abstract: The present study characterizes in detail the mycorrhizae of *Dermocybe cinnamomea* and *D. sanguinea* on *Picea abies*. The literature concerning the mycorrhizae of this genus is reviewed and the features described in it are compared with the characteristics of the mycorrhizae of *D. cinnamomea* and *D. sanguinea*.

Zusammenfassung: Die vorliegende Studie beschreibt ausführlich die Mykorrhizen von *Dermocybe cinnamomea* und *D. sanguinea* an *Picea abies*. Jene Literatur, die sich mit Mykorrhizen aus dieser Gattung befaßt, wird besprochen und die darin angeführten Merkmale mit den Charakteristika der hier aufgezeigten Mykorrhizen von *Dermocybe cinnamomea* und *D. sanguinea* verglichen.

In this series we try to describe comprehensively anatomical and morphological characters of different mycorrhizae formed by known fungi and trees. In addition mycorrhizae formed by unknown fungi will be characterized. These descriptions will be accompanied with a key allowing to determine the different mycorrhizae described up to the newest issue of the series. Colour prints of the described mycorrhizae will be published in the "Colour Atlas of Ectomycorrhizae" (Einhorn-Verlag, Schwäbisch-Gmünd, FRG).

I. Material and methods

1. The methods for researching ectomycorrhizae anatomically and morphologically are explained extensively and the value of the used features are discussed in detail in Agerer 1986, 1986a. In addition to the devices explained in Agerer 1986 an interference contrast microscope (Zeiss) is applied in the present study; interference contrast fotographs were made with an Olympus OM 4 and Agfaortho 25.

2. In contrary to the method used in Agerer 1986 (cryotome) the sections in this study were made by imbedding the mycorrhizae in Historesin (LKB) and cutting them with a rotation microtome. The sections were studied in a phase contrast microscope or in a Normarski's interference contrast microscope without dyeing. The sections were made after modifying the instructions distributed by LKB. The following steps were carried out:

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*Studies on Ectomycorrhizae IV: Agerer, Brand & Gronbach (1986).

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After fixation of the mycorrhizae (at least over night) in AFE (Acetic-Acid : Formaldehyde : Ethanol 70% = 5 : 5 : 90) the material was dehydrated in two steps: firstly ca. 6 hours in ethanol 70%, secondly ca. 6 hours in ethanol 90%. The mycorrhizae were then transferred into the infiltration solution (basic resin + activator) for at least 12 hours. The imbedding was carried out by adding the hardener to the infiltration solution (15 ml infiltration solution + 20 drops of the hardener) and placing the mycorrhizae in moulds. The polymerization was finished in ca. 12 hours at room temperature. The mycorrhizae were cut 3 μm thick with a LKB 2218 Historange and a D-knife, the sections were placed in destilled water, dried and covered with a cover glass after adding Entellan for making permanent slides.

II. Key for the mycorrhizae described up to now in this series

1. Mycorrhizae smooth, only under a dissection microscope somewhat hairy, with distinct rhizomorphs
   2. Mantle of mycorrhizae with laticiferous hyphae
      3. Surface of mantle with normal hyphae running more or less parallel to the surface of the mycorrhizae. . . . . *Lactarius deterrimus* (Agerer 1986a)
      3. Surface of mantle with short, obtuse hyphal ends protruding more or less perpendicularly to the surface of mantle. . . . . *Lactarius picinus* (Agerer 1986a)
   2. Mantle of mycorrhizae without laticiferous hyphae
      4. Surface of mantle pseudoparenchymatous, cells angular. . . *Russula ochroleuca* (Agerer 1986a)
      4. Surface of mantle a network of hyphae. . . . . *Russula xerampelina* (Agerer 1986a)
1. Mycorrhizae conspicuously hairy, furnished with many hyphae, hyphae partly densely interconnected to hyphal strands (rhizomorphs)
   5. Mycorrhizae yellow, some hyphae of mantle surface with brown contents, becoming distinctly dark brown in Melzer's reagent. . . . . *Dermocybe cinnamomea*
   5. Mycorrhizae slightly red or brownish-red, mantle without such hyphae. . . . *Dermocybe sanguinea*

III. Description of the mycorrhizae

1. **Dermocybe cinnamomea** (L. ex Fr.) Wünsche

Fig. 1, 2; Pl. 1, 2

Morphological characters

Mode of ramification: monopodial, but individual tips often bent and pretending a sympodial ramification, viz.: ultimate ends seeming shorter than side branches; length of unramified ends: -2(3,3) mm; diameter of unramified ends: (0,2)0,25-0,35 (0,4) mm; shape of unramified ends: often bent, longer ends often sinuous; structure of surface: hairy, hyphae partly interconnected to more or less hairy rhizomorphs. Colour of unramified ends: yellow; colour of tips: whitish yellow; colour of older parts: becoming more or less brownish.

Anatomical characters of surface

OUTER SURFACE OF MANTLE: Structure: plectenchymatous, composed of individually recognizable hyphae; size of hyphal cells: 3-4(5) μm; thickness of cell walls: not conspicuously thick; surface of the very tip: individual hyphae recognizable, diameter of hyphae 1,5-2(2,5) μm, some hyphae plasmatically brown.

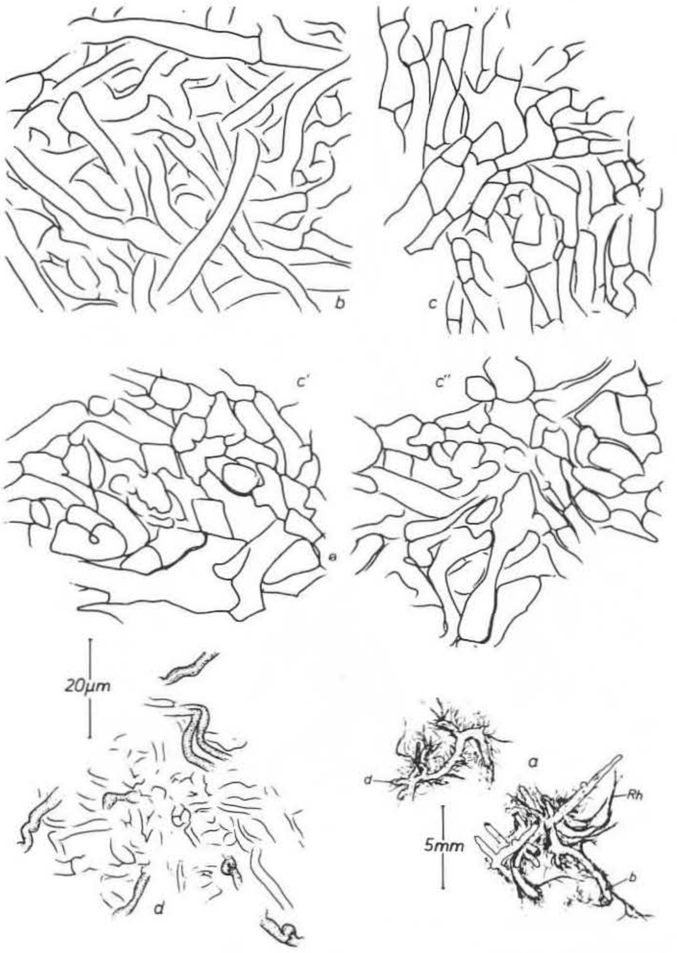

Fig. 1. - *Dermocybe cinnamomea* - a: Habit of mycorrhizae. - b: Surface view. - c, c', c'': Inner surface of mantle, different views. - d: Surface view of very tip. (All figs. from RA 10758, in Herb. R. Agerer).

RHIZOMORPHS: Shape in cross-section: flat or roundish; arrangement and diameter of hyphae: all hyphae of more or less the same diameter, (2)2,5-3,5 µm; thickness of cell walls: ca. 0,5 µm; colour of hyphae: membranaceous slightly yellowish, septae: with clamps; anatomoses: present, but not very frequent, contact-clamps very frequently present.

EMANATING HYPHAE: Shape and diameter: (1,5)2,5-3 µm, not conspicuously differentiated; thickness of cell walls: only slightly thick, less than 0,3 µm; colour of hyphae: inconspicuous; septae: with clamps and with contact-clamps.

CYSTIDIA: Shape and dimensions: short hyphal ends with round apices, plasmatically brown, 20-35 × 3-4 µm.

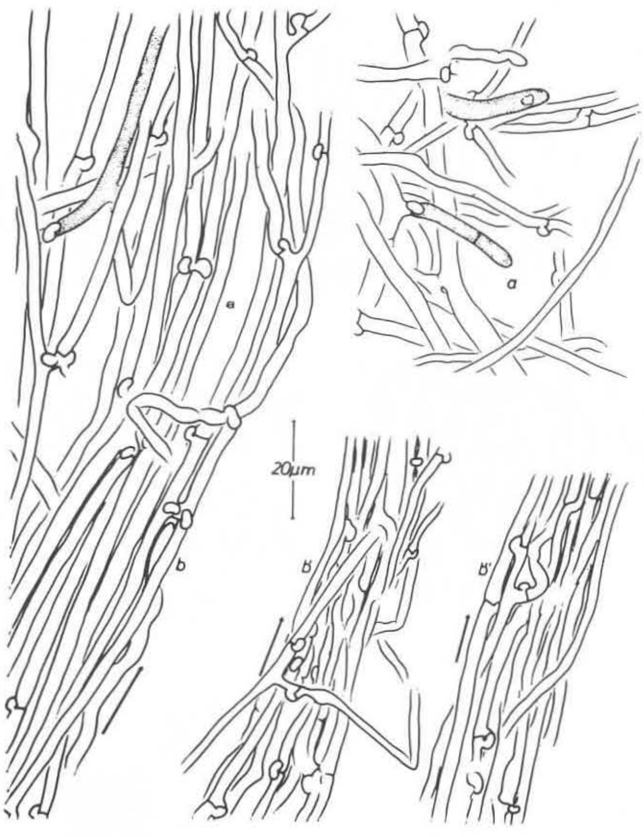

Fig. 2. - *Dermocybe cinnamomea* - a: Emanating hyphae. - b, b', b'': Different parts of rhizomorphs; arrows indicate the distal direction. (All figs. from RA 10758, in Herb. R. Agerer).

INNER SURFACE OF MANTLE: Arrangement of hyphae: irregular; diameter of hyphae: (3)4-6(11) µm.

Anatomical characters, cross-section

MANTLE: Thickness and differentiation: 15-25 µm, no distinct layers recognizable, hyphae losely or denser plectenchymatous, especially in outer regions losely woven, hyphae in inner parts of mantle more or less glued, intercellular spaces obviously sometimes filled with yellow pigment; cell-shape and dimensions: roundish to elongated, tangentially 4-10(25) µm, very seldom up to 35 µm, radially 2-4(6) µm, exceptionally up to 8 µm.

TANNIN CELLS: Number of rows: 1(2); shape and dimensions: tangentially elongated, irregularly compressed, 20-30(40) × 3-9(13) μm, cells of the eventually present inner row much thicker, up to 18 μm, some vestiges of an additional outermost layer of tannin cells are visible as very narrow, yellowish coloured irregularly formed lines.

HARTIG NET: Shape and dimensions of cortex cells: roundish or tangentially oval, seldom radially oval, tangentially (10)20-35(50), radially (10)15-25(30) μm; deepness of H'net: 3(4) rows of cortex cells, often reaching the endodermis; thickness of H'net: (1,5)2-3 μm, between outer cortex and tannin cells (2)2,5-4 μm, number of hyphal rows of H'net: 1 (very seldom two and then only in small parts); shape of H'net cells in section: in outer cortex cells more or less roundish or oval with distinct cell walls, in inner cortex cells often very long, up to 10(15) μm and hyphal cell walls very inconspicuous, often ramified on corners of the cell walls of the inner cortex cells, residual cell walls of cortex cells distinctly recognizable, in surface view: hyphae relatively weakly ramified.

Anatomical characters, longitudinal section

MANTLE: Shape and dimensions of the hyphae of the very tip: without differentiation into distinct layers, individual hyphae recognizable, tangentially 3-10(20) × (1) 1,5-2,5(3) μm; differentiation through older parts of the mantle: without distinct layers, hyphae tangentially 3-15 (20, very seldom up to 25) × 2-4(7) μm.

TANNIN CELLS: Shape and dimensions: strongly irregularly compressed, (25)40-90(130) × 3-9(13) μm.

HARTIG NET: Shape and dimensions of cortex cells: oriented somewhat obliquely backwards or nearly parallel to the root surface, oval or cylindrical or slightly rhombical, (40)70-90(120) × (10)15-25(30) μm.

Colour reaction in different reagents

Acetic-Fuchsin: brownish; a-Naphtol: ---; Ammonium-Hydroxide: ---; Brilliant-Kresyl-Blue: greyish blue-green; Chlorazol-Black E: greyish blue-green; Cotton-Blue: greyish blue-green; Erythrosin: brownish red; Fast-Green: green; Formol: ?; Guajak: ---; Iron-Sulfate: yellowish green, contents of brownish hyphae becoming umbre; KOH 15%: contents of brownish hyphae becoming dark; Kongo-Red: reddish; Magnesium-Acetate: ---; Malachit-Green: green; Martius-Yellow: slightly ochre; Melzer's Reagent: brownish hyphae conspicuously dark brown; Phenol: slightly red; Phenol-Anilin: slightly olive green; Phloxin B: slightly red; Stahl's EP-Reagent: ---; Sulfo-Vanillin: ---; Toluidin-Blue: violet blue.

Autofluorescence

WHOLE MYKORRHIZA: UV 254 nm: ---; UV 366 nm: ---. MANTLE AND RHIZOMORPHS: UV-filter 340-380 nm: bluish some hyphae distinctly copper orange (observed in lactic acid); Blue-filter 450-490 nm: yellowish green, other hyphae slightly orange-green, almost no distinct differences (observed in lactic acid).

Staining of nuclei

In emanating hyphae and in the hyphae of inner mantle surface mostly two nuclei per cell, seldom more (Method: aceto-carmine); without siderophilous granulation.

Material studied and method of identification

Deutschland, Bayern, Lkr. Dachau, Günding, Fichtenwald, 7.10.1984. (Fruitbody and mycorrhizae in Herb. R. Agerer No. RA 10758, M.). There were direct connections between fruitbody and mycorrhizae via rhizomorphs.

Comparison of the mycorrhizae of Dermocybe cinnamomea with those of Dermocybe sanguinea

a. Morphological and anatomical characters

One of the most evident differences between the mycorrhizae of *Dermocybe cinnamomea* and those of *D. sanguinea* lies in their colour. Whereas the mycorrhizae of *D. cinnamomea* are always more or less yellow sometimes with a slightly greenish tint, the mycorrhizae of *D. sanguinea* are reddish brown. The colours of both mycorrhizae remind of the colour of stipe bases of fruitbodies. The surface of both mycorrhizae is composed of hyphae, which are recognizable as individual structures, but in *D. sanguinea* the mycorrhizae are woollier with more emanating hyphae than it is the case in *D. cinnamomea.* Its mycorrhizae are in contrast to those of *D. sanguinea* furnished with more numerous and more distinct rhizomorphs.

The emanating hyphae are somewhat thicker in *D. sanguinea* than in *D. cinnamomea,* but the difference is not more than about 1 μm. The same holds true for the hyphae of the rhizomorphs. Another deviation between the two species refers to the cystidia like hyphal ends on the mycorrhizae of *D. cinnamomea,* which contain more or less brown substances; these can be dyed with Melzers reagent, getting a dark brown colour. Høiland (1983) did not mention such hyphae in his monograph. These elements could not be detected on the mycorrhiza of *D. sanguinea.*

Sectioned mycorrhizae show additional differences. The mantle of *D. sanguinea* seems to be thinner and more loosely woven than the mantle of *D. cinnamomea.* As a consequence of this the mantle hyphae of *D. sanguinea* are not as flattened as the more densely packed hyphae of *D. cinnamomea.* The hyphae of the mantle seem to be somewhat thicker in *D. cinnamomea* than in *D. sanguinea.* Only *D. sanguinea* forms next to the tannin cells a distinct layer characterized by thicker hyphae. It is not clear, if the differences referring to differently thick Hartig nets (somewhat thicker between the outer cortex cells in *D. cinnamomea* than in *D. sanguinea*) are suitable for delimiting the two mycorrhizae. But it seems that the very inconspicuous cell walls of the Hartig net and their obviously longer cells in *D. cinnamomea* can be used to distinguish the mycorrhizae of *D. cinnamomea* and *D. sanguinea.*

b. Chemical reactions

Some reagents cause different colour changes. Brillant-Kresyl-Blue causes in *D. sanguinea* a bright blue, in *D. cinnamomea* a greyish blue-green colour, probably this difference is due to the difference in colour of the untreated mycorrhizae. Chlorazol-Black dyes the mantle of the mycorrhizae of *D. sanguinea* greyish olive-green, those of *D. cinnamomea,* however, greyish green. Phenol and Phenol-Anilin produce no colour reaction in *D. sanguinea,* whereas Phenol tinges the mycorrhizae of *D. cinnamomea* slightly red, Phenol-Anilin slightly olive-green.

Høiland (1983) researched the coloured contents of the fruitbodies of the species of the genus *Dermocybe.* He divided the species into seven different chemical groups. *Dermocybe cinnamomea* and *D. sanguinea* belong to different groups. *Dermocybe cinnamomea* is included in the group of species which contain flavomannin-6,6'-dimethylether and the pigments of the dermorubin-series, whereas *D. sanguinea* belongs to a group of species which is characterized by substances of the dermorubin- and the dermocybin-series. These differences in the chemical contents may be the reason for the deviating colour-reactions of the two mycorrhizae. Høiland, however, did not apply the above mentioned reagents except for KOH.

c. Autofluorescence

The emanating hyphae of the mycorrhizae of *D. cinnamomea* show in UV-light in contrary to those of *D. sanguinea* here and there a bright copper-orange tint, whereas parts of the hyphae are slightly bluish. All the emanating hyphae and the hyphae of the mantle of *D. sanguinea* are coloured in a similar way (bluish-green). In blue light the differences between the two mycorrhizae are not as great as in UV light.

d. Nuclei and Contact-clamps

The contact-clamps seem to be characteristic for several mycorrhizae of *Dermocybe* species as they do for some species of other genera, e.g. species of the genus *Cortinarius* and *Hebeloma* (in prep.). If contact-clamps occur they obviously increase the normal number of two nuclei per cell to three or more (see fig. 5). Presently it is not possible to show the way by which the "contact-clamps" are formed.

Mycorrhizae of Dermocybe cinnamomea as treated in literature

The single and only scientist who published some anatomical and morphological data on the mycorrhiza of *Dermocybe cinnamomea* is Masui (1927). Masui identified the mycorrhiza of this species by hyphal connections between the fruitbodies and *Pinus densiflora* resp. *Populus tremula.*

His morphological characterization of the mycorrhizae on *Pinus* fits well — exclusively of the dichotomous branching characteristic for mycorrhizae of the genus *Pinus* — with the description given above. This holds true for the sections of the mycorrhizae. Masui mentioned a rather thin mantle (7-20 μm thick) and delineated individually recognizable hyphae of a relatively loosely woven plectenchymatous mantle, and a well developed Hartig net. In addition Masui drew hyphae of this species showing the typical "contact-clamp-connexions" which connect neighbouring hyphae. This special type of clamp connexions works obviously merely as a device to hold hyphae together. Whereas normal anastomoses may function in addition as pathways for different substances which may be transported in the hyphae.

Masui mentioned that thicker roots may be infected intracellularly by *Dermocybe cinnamomea.* In our studies we did not look for infections of older roots. We could, however, find some balloon-like intrusions of the Hartig net into the cortex cells. But this feature occurred only sporadically and is therefore not characteristic for this mycorrhiza. The mycorrhizae of *D. cinnamomea* formed on roots of *Populus tremula* as reported by Masui (1927) differ in some details from the mycorrhizae made on *Pinus densiflora.* A very astonishing fact is the deviating colour. The mycorrhizae built on *Populus tremula* should be yellow-orange. Such a difference in colour could in our opinion be a hint that the mycorrhiza forming fungus could well be another species, because the colour of the mycorrhizae in the genus *Dermocybe* is seemingly closely related to the colour of the stipe base of fruitbody. The thicker mantle (15-39 μm) and the rather frequent intracellular infections of the cortex cells may be some other hints to emphasize the fact that the mycorrhizae are caused by another species, though it cannot be excluded that these differences are depending on the host-tree.

It may be that the so-called "safrangelbe Mykorrhiza" studied by Björkman (1942) and Mikola (1962) and mentioned by Melin (1936) is very similar to the mycorrhiza of *D. cinnamomea,* though the mycorrhizae of *D. cinnamomea* have not such a distinct suffron tint. Unfortunately there are no detailed descriptions of this type of mycorrhiza. In addition several yellow mycorrhizae can be found but they differ in some morphological and anatomical aspects (unpubl.). Therefore one cannot be sure what special type of mycorrhiza was considered by Melin (1936) and Björkman (1942), but Björkman showed a picture, and it makes clear that the "safrangelbe Mykorrhiza" is much more woolly than the mycorrhiza of *D. cinnamomea.*

2. **Dermocybe sanguinea** (Wulf. ex Fr.) Wünsche — Fig. 3, 4, 5; Pl. 3, 4

Morphological characters

Mode of ramification: monopodial; length of unramified ends: -2,0(3,0) mm; diameter of unramified ends: 0,25-0,35(0,46) mm; shape of unramified ends: especially longer ends more or less sinuous; structure of surface: woolly, hyphae connected to conspicuous rhizomorphs. Colour of unramified ends: reddish brown; colour of tips: reddish brown; colour of older parts: more or less brown.

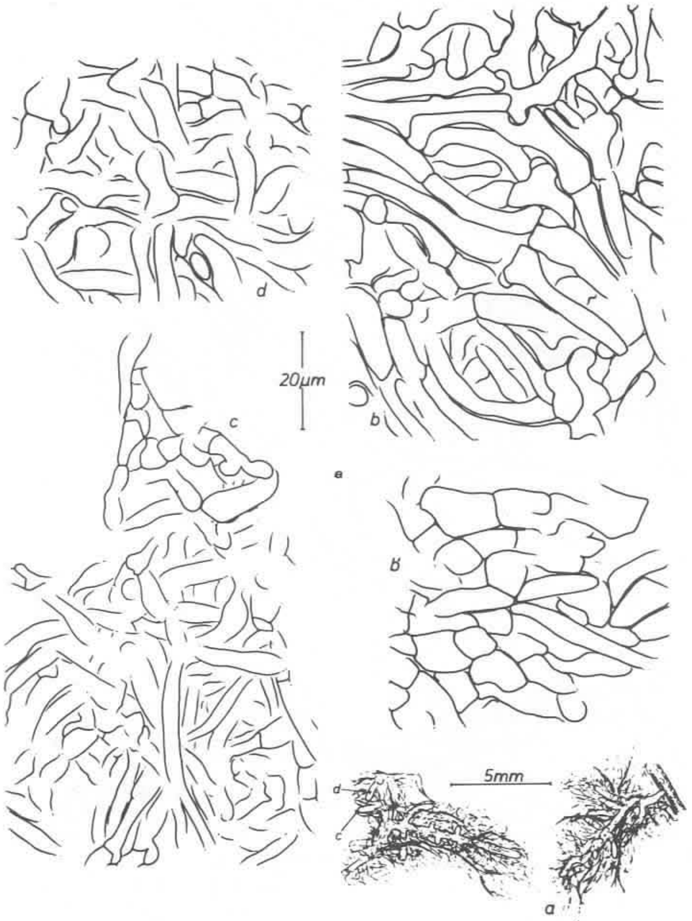

Fig. 3. - *Dermocybe sanguinea* - a: Habit of mycorrhizae. - b, b': Inner surface of mantle, different views. - c: Surface view of very tip. - d: Surface view, directly beneath the emanating hyphae. (All figs. from RA 10743, in Herb. R. Agerer).

Anatomical characters of surface

OUTER SURFACE OF MANTLE: Structure: plectenchymatous, composed of individually recognizable hyphae; size of hyphal cells: 4-5,5 µm; thickness of cell walls: slightly thick-walled; surface of the very tip: individual hyphae recognizable, diameter of hyphae 2-4 µm.

RHIZOMORPHS: Shape in cross-section: more or less roundish; arrangement and diameter of hyphae: all hyphae more or less of the same shape, 3-4 µm in diam.; thickness of cell walls: ca. 0,5 µm; colour of hyphae: membranaceous slightly brownish, septae: with clamps, contact-clamps very frequent; anastomoses: present.

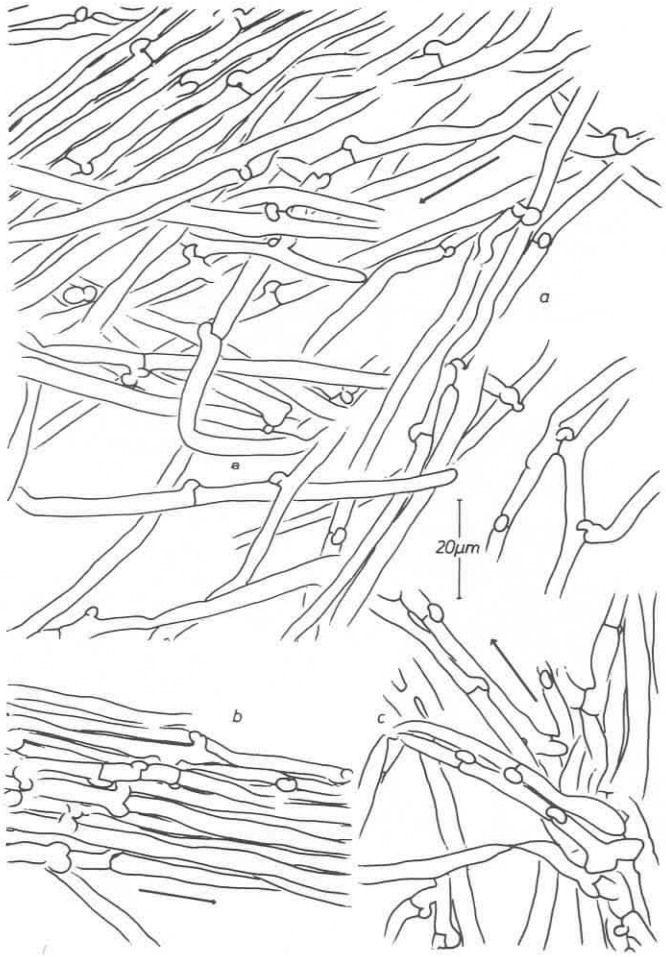

Fig. 4. - *Dermocybe sanguinea* - a, c: Emanating hyphae. - b: Part of rhizomorph; arrows indicate the distal direction. (All figs. from RA 10743, in Herb. R. Agerer).

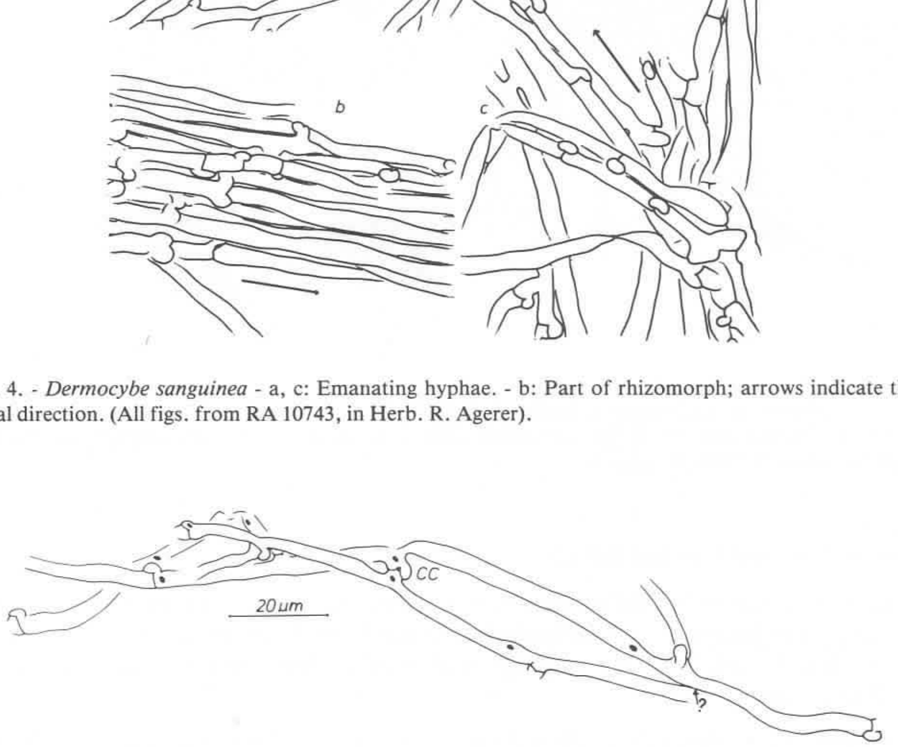

Fig. 5. - *Dermocybe sanguinea* - Hyphae connected by "contact-clamp", and nuclei dyed with aceto-carmine. CC = "contact-clamp", ? = not clear, if "contact-clamp", anastomosis or no connexion present. (Fig. from RA 10743, in Herb. R. Agerer).

EMANATING HYPHAE: Shape and diameter: not conspicuously specialized, 3-3,5 μm in diam., thickness of cell walls: slightly thick-walled; colour of hyphae: membranaceous slightly brownish; septae: with clamps, sometimes hyphae with secondary septae, viz.: clampless septae present.

CYSTIDIA: None found.

INNER SURFACE OF MANTLE: Arrangement of hyphae: short or longer, nyphae sometimes arranged in whirls; diameter of hyphae: 3-5(6) μm.

Anatomical characters, cross-section

MANTLE: Thickness and differentiation: (5)10-15(20) μm, losely plectenchymatous, no distinct layers recognizable, with exception of the hyphae next to the tannin cells; cell-shape and dimensions of different layers; sectioned hyphae mostly roundish, not flattened, tangentially 3-10(30) μm, radially 2-4 μm, older parts of mycorrhizae with thicker hyphae, 3-5(7) μm.

TANNIN CELLS: Number of rows: 1(2); shape and dimensions: tangentially elongated, oval or elliptical often very irregularly shaped, sometimes tapering, (20)25-35(40) × (3)5-13(17) μm, some vestiges of an outer row of tannin cells are visible as very narrow, yellowish coloured irregularly shaped lines.

HARTIG NET: Shape and dimensions of cortex cells: roundish or more or less tangentially oval, tangentially (8)20-35(45) μm, radially (10)15-25 (35, very seldom 45) μm; deepness of H'net: 3(4), almost reaching the endodermis; thickness of H'net: 2-3 μm, next to the tannin cells up to 4 μm, number of hyphal rows of H'net: 1; shape of H'net cells in section: elongated oval, up to 5 μm long, exceptionally up to 10 μm, hyphal walls and residual cell walls of the cortex cells distinctly recognizable, in surface view: relatively broad and not as ramified as in the typical palmetti type of Hartig net.

Anatomical characters, longitudinal section

MANTLE: Shape and dimensions of the hyphae of the very tip: irregularly arranged, without differentiation into distinct layers, individual hyphae recognizable, tangentially 3-10(20) μm, radially 2-3(4) μm, cell walls less distinct as in other parts of the mantle; differentiation through older parts of the mantle: no distinct layers recognizable only the hyphae next to the tannin cells somewhat thicker; tangentially 3-15(35), radially 2-4(5) μm, next to the tannin cells tangentially 3-10 μm, radially 3-6 μm.

TANNIN CELLS: Shape and dimensions: elongated, tapering or irregularly oval or slightly rhombical, 35-63(90) × (3)5-13(17) μm.

HARTIG NET: Shape and dimensions of cortex cells: oval or cylindrical or slightly rhombical, somewhat obliquely oriented inside backwards or almost parallel to the root surface, tangentially (35)45-95(110) μm, radially (10)15-25(35) μm.

COLOUR REACTION IN DIFFERENT REAGENTS: Acetic-Fuchsin: brownish red; a-Naphtol: ---; Ammonium-Hydroxide: ---; Brilliant-Kresyl-Blue: bright blue, densely packed hyphae more or less greenish; Chlorazol-Black E: greyish olive green; Cotton-Blue: slightly blue; Erythrosin: slightly red; Fast-Green: green, densely packed hyphae brownish green; Formol: ---; Guajak: ---; Iron-Sulfate: slightly yellowish-green; KOH 15%: ---; Kongo-Red: slightly reddish brown; Magnesium-Acetate: ---; Malachit-Green: green; Martius-Yellow: slightly ochre yellow; Melzer's Reagent: slightly yellowish brown; Phenol: ---; Phenol-Anilin: ---; Phloxin B: slightly red; Stahl's EP-Reagent: ---; Sulfo-Vanillin: ---; Toluidin-Blue: violet blue.

Autofluorescence

WHOLE MYCORRHIZA: UV 254 nm: ---; UV 366 nm: ---. MANTLE AND RHIZOMORPHS: UV-filter 340-380 nm: slightly bluish green (observed in water); Blue-filter 450-490 nm: slightly green (observed in water).

Staining of nuclei

The emanating hyphae contain mostly two nuclei per cell, but sometimes more. This increase in number is probably due to the producing of contact clamps. Hyphae with contact-clamps may contain three or more nuclei (s. fig. 5); method: acetocarmine.

Material studied and method of identification

Deutschland, Bayern, Lkr. Fürstenfeldbruck, Fichtenwald bei Buchenau, 2.10. 1984 (Fruitbody and mycorrhizae in Herb. R. Agerer No. 10743, M.). There were connections between the fruitbody and the mycorrhizae via rhizomorphs.

Comparison of the mycorrhiza of Dermocybe sanguinea with those of D. cinnamomea

(See comments on *Dermocybe cinnamomea*).

Mycorrhizae of Dermocybe sanguinea as treated in literature

Zak (1971) published a fotograph of the mycorrhizae formed by *Dermocybe sanguinea* with *Pseudotsuga menziesii.* As far a can be seen the habit of the mycorrhizae resembles our mycorrhizae found on *Picea abies.* Zak further mentioned a red colour seeping in the medium if the mycorrhizae were treated with KOH, NH_4OH and yellow-orange if treated with Guaiacol. We did not see such reactions. The reason for this is probably that Zak used the whole mycorrhiza to test the reactions whereas we dyed only small fragments of mantle and rhizomorphs, because we have to use a great set of chemical reagents, and therefore we must be economically with the material. Therefore the eluated pigment is not as concentrated as it was in

Zak's researches. On the other hand we do not use Guaiacol. But it is a good characteristic that the red pigments of *Dermocybe* mycorrhizae are eluated very remarkably into the storage medium, viz: AFE or ethanol. If additional material will be available we will test the mycorrhizae after Zak's method.

Mycorrhizae of the genus Dermocybe as treated in literature

There are only a few characterizing researches of *Dermocybe* mycorrhizae in literature in addition to the above mentioned publication of Masui (1927) on the mycorrhizae of *Dermocybe cinnamomea.*

Peyronel (1963) mentioned the mycorrhizae of *Dermocybe cinnabarina* and stressed their vermillion colour. This colour reminds once more of the colour of the stipe of this species (unpubl. data).

Zak (1971) characterized the species *Dermocybe croceifolia* (= *Dermocybe phoenicea*, ss. Zak 1973), *D. sanguinea* and *D. semisanguinea* by fotographs and by some special chemical reactions. With these researches he wanted to show the good chances which exist to identify and to characterize mycorrhizae with the aid of morphology, chemical reactions and with autofluorescence. And probably only therefore he renounced the use of anatomical characteristics. But he was able to distinguish the mentioned mycorrhizae already by these few features. The identification was possible by tracing hyphal connexions between fruitbodies and underlying mycorrhizae. The shown morphological features of the mycorrhizae of *D. croceifolia, D. sanguinea* and *D. semisanguinea* fit well with the morphology of our up to now found mycorrhizae of the genus *Dermocybe.*

Zak (1973) showed fotographically the mycorrhiza of *Dermocybe phoenicea* (sub. nomine *Cortinarius semisanguineus* in Zak 1971). This specimen, too, shows similarities with the mycorrhizae characterized in the present paper. Zak once more demonstrated that mycorrhizae can have distinct colours in UV light and he stressed for *Dermocybe phoenicea* a typical orange yellow colour.

Zak (1974) characterized the arbutoid mycorrhiza of *Dermocybe zakii* with *Arbutus menziesii.* Because of the similarity referring to gross morphology of arbutoid mycorrhizae and ectomycorrhizae the arbutoid mycorrhiza found by Zak should be discussed in the present paper, too. Zak gave an extensive description and fotographs. The rhizomorphs attached to the wefty bright golden yellow mycorrhizae are very conspicuous. The thin, prosenchymatic mantle (= hyphae individually recognizable) and the presence of clamps are further features which show the similarity with the other known mycorrhizae of the genus *Dermocybe.* Again Zak (1974) could show some special reactions with KOH and NH_4OH. The mycorrhizae changed their colour to dull yellow and copper vinaceous, whereas with many other tested reagents no changes occurred.

Acsai & Largent (1983) researched the arbutoid mycorrhizae of *Arbutus menziesii, Arctostaphylos uva-ursi* and *A. manzanita.* They identified the mycorrhizae formed by *Dermocybe* cf. *zakii* by tracing the rhizomorphs and mycelia between fruitbodies and mycorrhizae. Unfortunately Acsai & Largent described the mycorrhizae only with a few words and without any fotographs and drawings. The thin (10-25 μm) prosenchymatic mantle (= hyphae individually recognizable), the presence of clamps, and the wefty appearance of the mycorrhizae show the similarity of this mycorrhiza with the other known mycorrhizae of the genus *Dermocybe*. But they could not find rhizomorphs. The golden brown colour stresses once more the importance of this feature for characterization of the *Dermocybe* mycorrhizae. The difference in colour between the mycorrhizae of *D.* cf. *zakii* (Acsai & Largent 1983) and the mycorrhizae of *D. zakii* characterized by Zak (1974) makes us suppose that Acsai and Largent probably found another species of *Dermocybe* and not the supposed *D. zakii*.

IV. Acknowledgements

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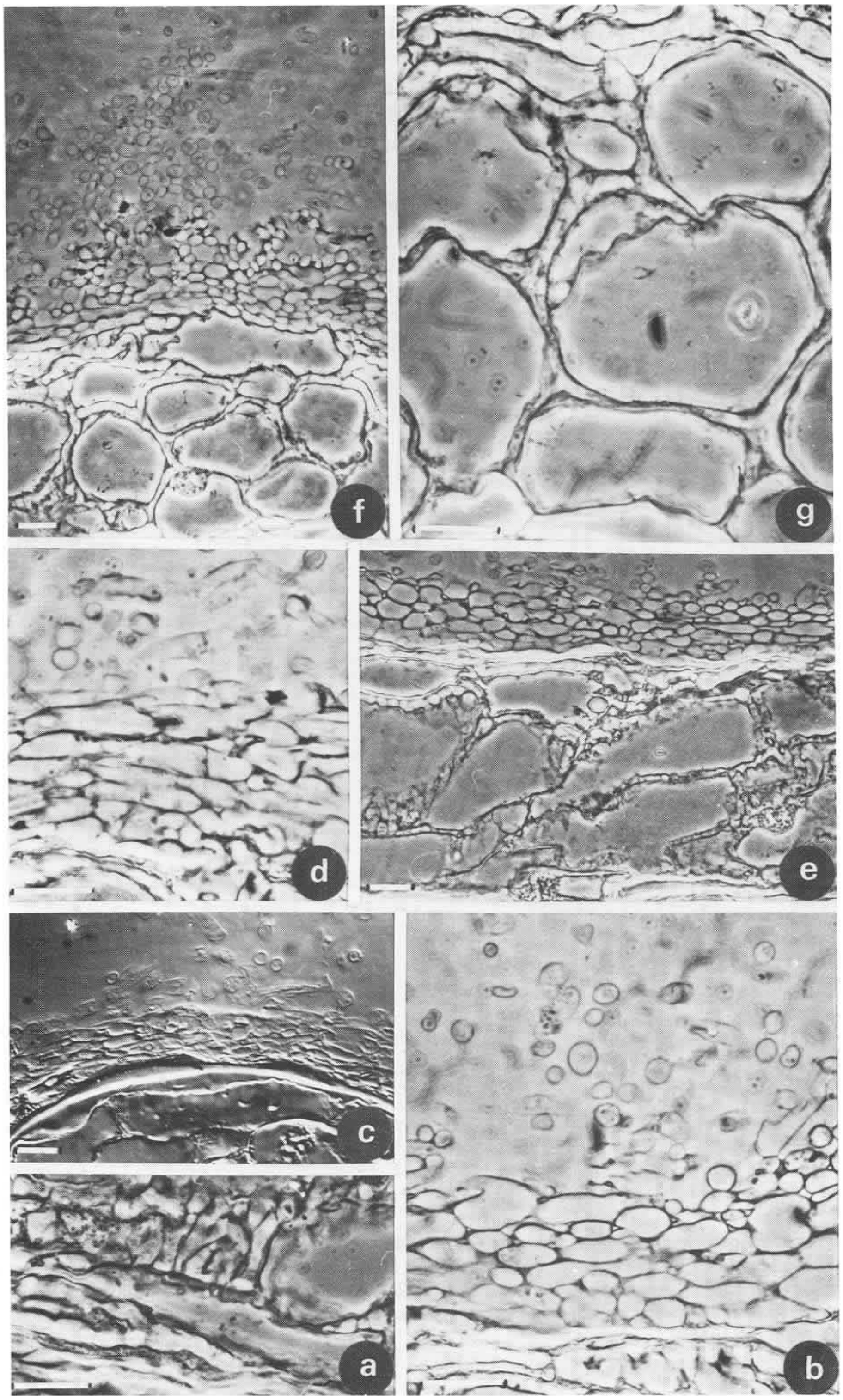
Pl. 1. - *Dermocybe cinnamomea* - a: Longitudinal section, surface view of Hartig net. - b: Longitudinal section, mantle with emanating hyphae. - c: Longitudinal section, very tip. - d: Cross section, mantle with emanating hyphae. - e: Longitudinal section, from endodermis to mantle. - f: Cross section, from endodermis to mantle with emanating hyphae. - g: Cross section, cortex cells from endodermis to mantle, with Hartig net. (Bar = 10 μm, all figs. from RA 10758).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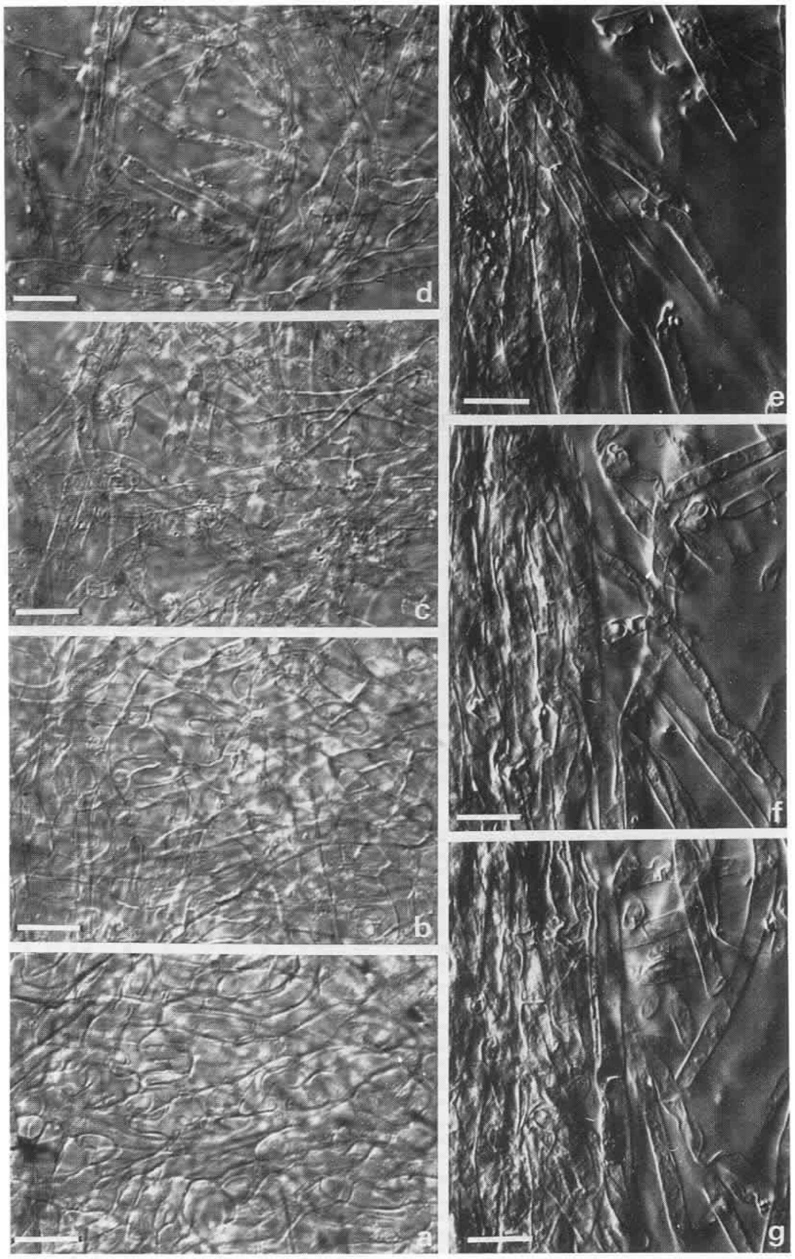
Pl. 2. - *Dermocybe cinnamomea:* a-d, views of mantle in different levels of focus, always from the same position. - a: Inner mantle surface. - b: Focus above a. - c: Focus beneath d. - d: Outer mantle surface. e-g, views of half a rhizomorph in different levels of focus, always from the same position. - e: Outer surface of rhizomorph. - f: Level of focus between e and g. - g: Middle of rhizomorph. (Bar = 10 μm, all figs. from RA 10743).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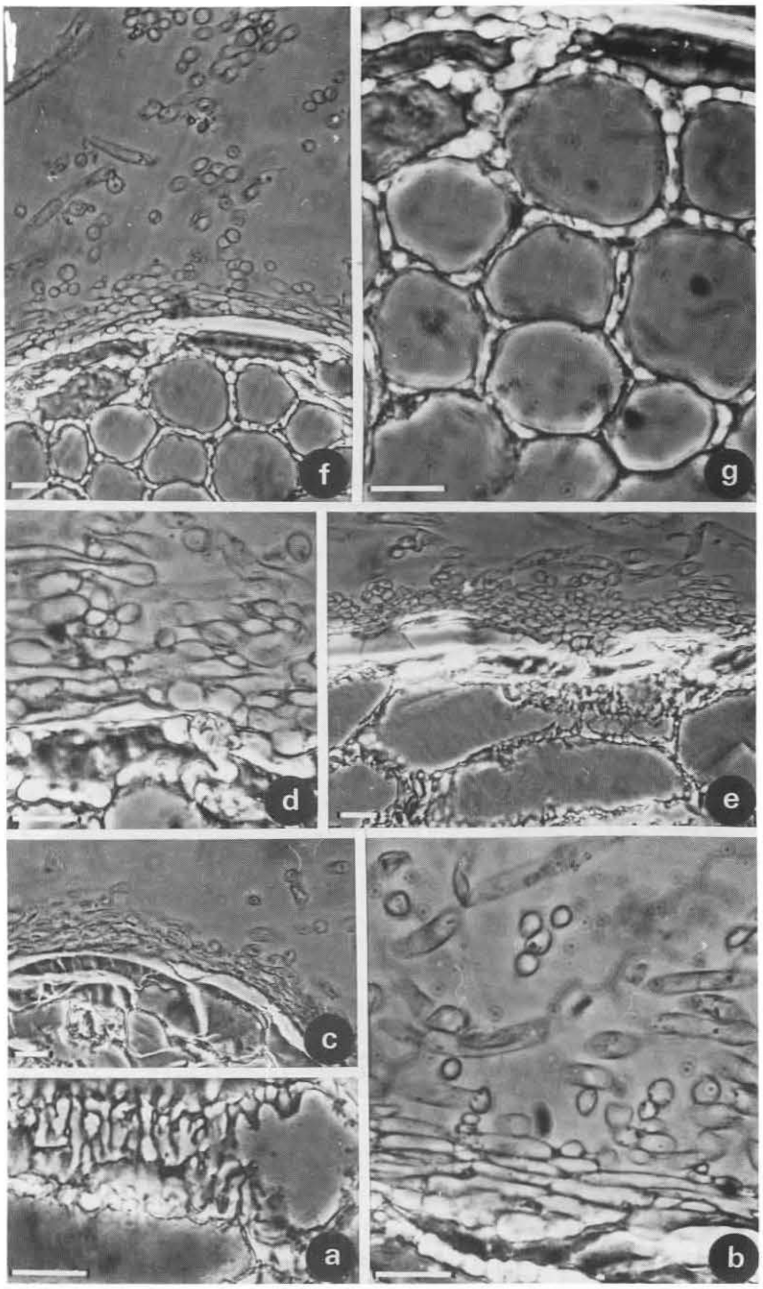
Pl. 3 - *Dermocybe sanguinea* - a: Longitudinal section, surface view of Hartig net. - b: Longitudinal section, mantle with emanating hyphae. - c: Longitudinal section, very tip. - d: Cross section, mantle with emanating hyphae. - e: Longitudinal section, from middle of cortex to mantle. - f: Cross section, from cortex cells near endodermis to mantle with emanating hyphae. - g: Cross section, cortex cells from endodermis to mantle, Hartig net. (Bar = 10 μm, all figs. from RA 10743).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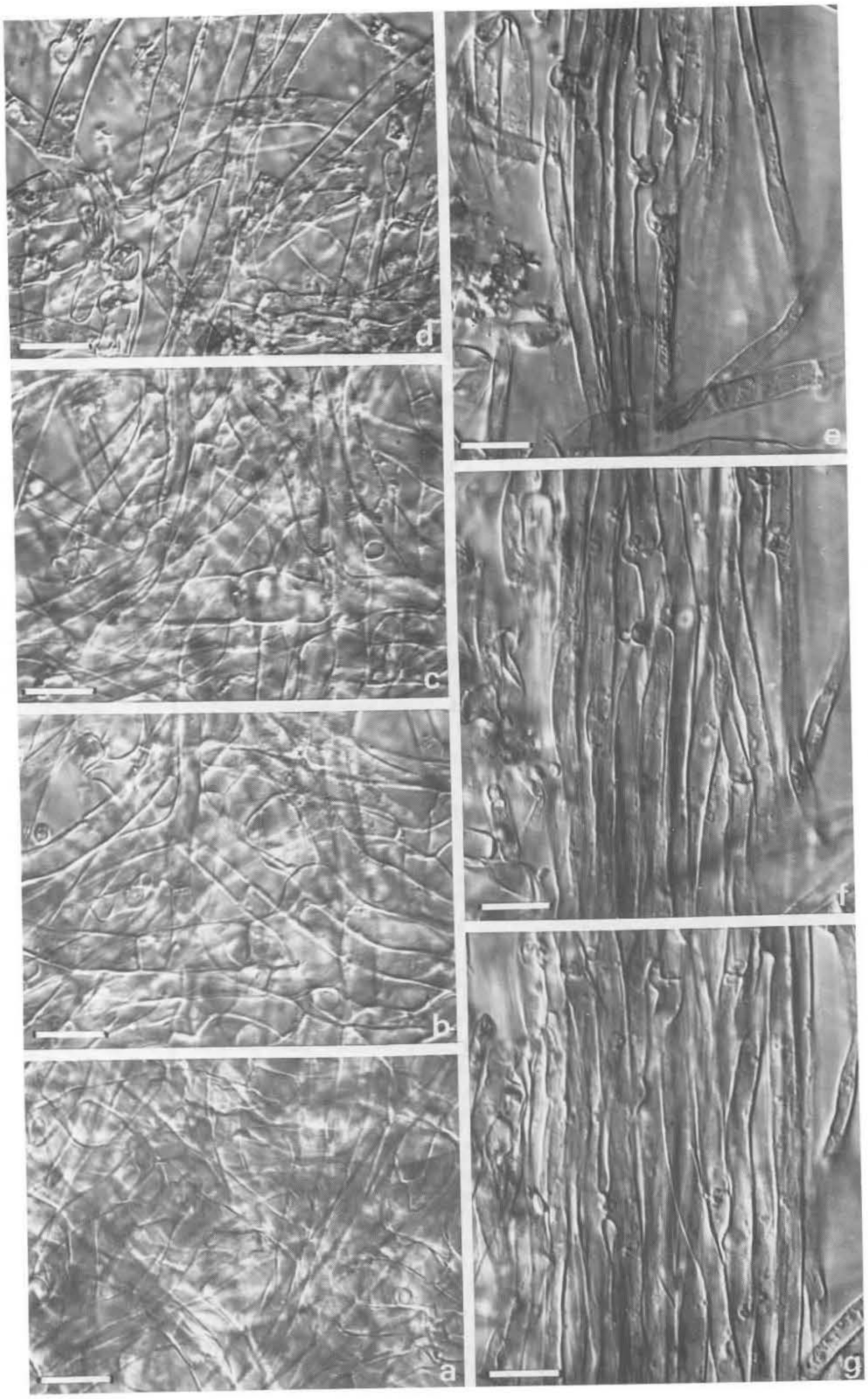
Pl. 4. - *Dermocybe sanguinea* - a-d, views of mantle in different levels of focus, always from the same position. - a: Inner mantle surface. - b: Focus above a. - c: Focus beneath d. - d: Outer mantle surface. - e-g, views of a rhizomorph in different levels of focus, always from the same position. e: Surface of rhizomorph. - f: Level of focus between e and g. - g: Middle of rhizomorph. (Bar = 10 μm, all figs. from RA 10743).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